

Removable folded sterile gauze compression

Easily removable folded sterile gauze compression

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Abstract

Aim: This study aims to evaluate patients who underwent intra-abdominal packing due to bleeding during emergency or elective surgeries and to introduce the Easily Removable Folded Sterile Gauze Compression Method (ERFSGCM) and its clinical outcomes.

Materials and Methods: Patients who applied packing for uncontrolled bleeding between 2015 and 2023 were retrospectively analyzed. Two groups were compared: traditional packing and ERFSGCM. Data included demographics, Charlson Comorbidity Index (CCI), INR levels, surgical details, trauma type, bleeding site, packing method, number of quadrants packed, blood loss and transfusions, abdominal closure technique, timing of fascia closure, recurrent bleeding, number of surgeries, postoperative complications (renal failure, ischemia, respiratory distress, wound infection), Clavien-Dindo scores, ventilation duration, ICU/hospital stay, and mortality.

Results: Twenty-nine patients were included: 25 with traditional packing and 4 with ERFSGCM. Mean age was 51.6 ± 19.2 years. No significant difference was found in demographics or CCI. Emergency surgeries accounted for 55.2%. Recurrent bleeding, number of surgeries, acute renal failure, and mortality were significantly lower in the ERFSGCM group (p < 0.05). All ERFSGCM patients had Clavien-Dindo scores of 2, while traditional packing patients scored above 2 (p < 0.001). Fascia closure was more frequent in the ERFSGCM group (p = 0.030).

Discussion: ERFSGCM may reduce the need for re-laparotomy and improve outcomes compared to traditional packing. Further studies with larger cohorts are needed to confirm its efficacy.

Keywords

bleeding, hemorrhage, compression, packing, trauma

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Introduction

Hemorrhage remains the leading cause of preventable death in trauma patients [1–3]. The pressure-packing technique, initially used during World War II, was largely abandoned due to infection and coagulopathy-related rebleeding, until Lucas and Ledgerwood's prospective study of 637 patients reintroduced and evaluated its efficacy [4].

Management of hemorrhagic trauma and postoperative coagulopathy remained uncertain until Rotondo et al. (1993) highlighted the “triad of death”—acidosis, coagulopathy, and hypothermia—prompting the adoption of damage control surgery with resuscitation. Although it was first attempted a century ago and applied during the last century, its significance was only recently recognized, with Rotondo's study establishing it as the primary approach for major trauma. Currently, early recognition of bleeding remains a key determinant of survival [5–6]. The goal of post-trauma laparotomy is to control hemorrhage from intra-abdominal organs, vascular injuries, and retroperitoneal trauma.

Routine four-quadrant packing is widely practiced for hemorrhage control [7–9]. However, consensus is lacking on whether packing should target all quadrants or only the bleeding site, and the optimal abdominal closure technique after damage control surgery remains unclear [10]. This study evaluates patients who underwent packing for intra-abdominal bleeding during emergency or elective surgery and introduces the Easily Removable Folded Sterile Gauze Compression Method (ERFSGCM) as a potential alternative.

Traditional Packing Method

1. Direct packing of the bleeding site with dry 15×40 cm gauze.
2. Additional gauze was placed adjacent to enhance tamponade.
3. Manual pressure applied for 10–15 minutes.
4. If hemostasis was inadequate, further gauze was applied to the edges; in extensive bleeding, laparotomy pads (40×40 cm) were also used.
5. The bowel was protected with a wet towel.
6. Temporary abdominal closure was performed with single-layer skin sutures using 1-0 material [11].

Easily Removable Folded Sterile Gauze Compression Method

ERFSGCM uses 30-meter sterile gauze strips instead of traditional compresses. The gauze is unfolded and folded layer by layer with forceps to achieve compression, and one end is exteriorized through a small abdominal incision. This design enables bedside removal of the packing 48 hours postoperatively, eliminating the need for re-laparotomy.

Materials and Methods

Clinical Data Collection

Inclusion: All cases that underwent packing for uncontrollable bleeding at Health Sciences University Tepecik Training and Research Hospital (Izmir/Turkey) from 2015 to 2023 were retrospectively reviewed using the hospital database (Probel HBYS v1, Izmir, Turkey).

Exclusion: Cases with missing data in the hospital records were excluded from the study.

Patients were classified into two groups: traditional packing and ERFSGCM. Data collected included demographics, Charlson Comorbidity Index (CCI), preoperative INR, surgical indication

and type, iatrogenic bleeding in elective cases, trauma type, bleeding site, packing method, number of quadrants packed, intraoperative blood loss and transfusions, abdominal closure technique, timing of final fascial closure, recurrent bleeding after unpacking, number of surgeries, postoperative complications (acute renal failure, ischemic events, respiratory distress, wound infection), Clavien-Dindo scores, duration of mechanical ventilation, ICU and hospital stay, and mortality. Statistical analyses were performed.

Statistical Analysis

Statistical analyses were performed using SPSS v. 25. Normality was assessed with Kolmogorov-Smirnov and Shapiro-Wilk tests. Data were expressed as mean $\pm$ SD for normally distributed variables and as median (Q1–Q3) for non-normal variables; categorical data were presented as frequency and percentage. Group comparisons used the independent samples t-test or Mann-Whitney U test for continuous variables, and Pearson's chi-square or Fisher's exact test for categorical variables. Univariate analyses identified potential risk factors, followed by multivariate analyses to determine independent predictors. A p-value < 0.005 was considered statistically significant.

Ethical Approval

This study was approved by the Ethics Committee of Health Sciences University, Izmir Tepecik Training and Research Hospital (Date: 2024-03-24, No:2024/03-24).

Results

Twenty-nine patients were included: 25 underwent traditional packing and 4 applied ERFSGCM. The mean age was 51.6 ± 19.2 years (traditional: 53.7 ± 18.8 ; ERFSGCM: 38.5 ± 18). Overall, 19 patients (65.5%) were male. In the traditional group, 15 (60%) were male and 10 (40%) female, while all ERFSGCM patients were male. No significant differences were observed between groups regarding demographic distribution ($p = 0.143$, $p = 0.268$). The median CCI was 4 (0–6) overall, 4 (1–6) in the traditional group, and 0 (0–3) in the ERFSGCM group ($p = 0.070$). Among all



Figure 1. Illustration of ERFSGCM

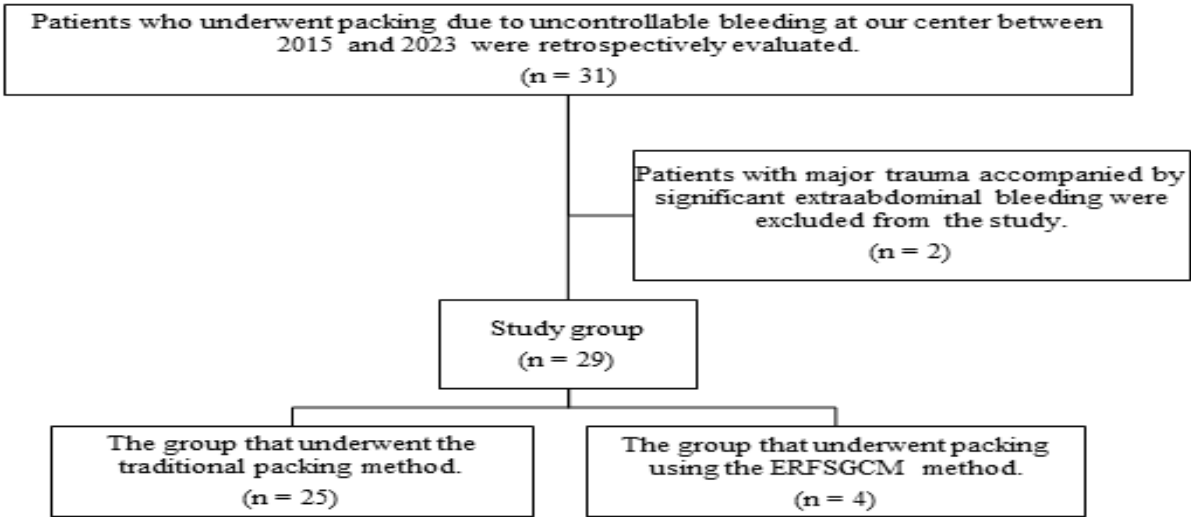


Figure 2. Flow chart of study design

Table 1. Statistical analysis results

	All Patients	Traditional Packing	ERFSGCM	p-value
	n=29	n=25	n=4	
Age, mean±SD	51.6±19.2	53.7±18.8	38.5±18	0.143
Gender, n (%)				0.268*
Male	19 (65.5)	15 (60)	4 (100)	
Female	10 (34.5)	10 (40)	0	
CCI, median (Q1-Q3)	4 (0-6)	4 (1-6)	0 (0-3)	0.070
Type of operation, n (%)				0.606*
Emergency	16 (55.2)	13 (52)	3 (75)	
Elective	13 (44.8)	12 (48)	1 (25)	
Type of trauma, n (%)				0.080
Blunt	9 (56.3)	9 (69.2)	0	
Penetrating	3 (18.8)	2 (15.4)	1 (33.3)	
High-energy	4 (25)	2 (15.4)	2 (66.7)	
Bleeding site, n (%)				0.655
Liver	11 (37.9)	8 (32)	3 (75)	
Presacral area	8 (27.6)	7 (28)	1 (25)	
Retroperitoneal area				
2a	5 (17.2)	5 (20)	0	0.444
2b	2 (6.9)	2 (8)	0	
2c	1 (3.4)	1 (4)	0	
Other	2 (6.9)	2 (8)	0	
Intraoperative blood loss (L), median (Q1-Q3)	1.7 (1.2-3.0)	1.8 (1.1-3.0)	1.5 (1.2-1.6)	0.043
Number of recurrent active bleeding episodes, median (Q1-Q3)	1 (0-1)	1 (0-1)	0 (0-0)	0.013
Number of surgeries during admission, median (Q1-Q3)	2 (1-3)	2 (1.5-3.5)	1 (1-1)	0.042*
Postoperative ARF, n (%)	15 (51.7)	15 (60)	0	0.030*
Abdominal anterior wall fascia closed successfully, n (%)	13 (44.8)	9 (36)	4 (100)	1.000*
Intraabdominal abscess, n (%)	3 (10.3)	3 (12)	0	1.000*
Wound site infection, n (%)	3 (10.3)	3 (12)	0	0.647
Length of intensive care unit stay, median (Q1-Q3)	5 (4-7.5)	5 (3-8)	4.5 (4-5.8)	0.647
Length of hospital stay, median (Q1-Q3)	16 (7-41)	20 (6.5-43.5)	15.5 (10.5-16.8)	<0.001
Clavien-Dindo Score, n (%)				
2	4 (13.8)	0	4 (100)	
3	3 (10.3)	3 (12)	0	
4	4 (13.8)	4 (16)	0	
5	18 (62.1)	18 (72)	0	
Mortality, n (%)	18 (62.1)	18 (72)	0	0.014*

*Fisher's Exact test was used.
Abbreviations: ARF, Acute Renal Failure; CCI, Charlson's Comorbidity Index; ES, Erythrocyte Suspension.

Table 2. Multivariate analysis for mortality

	p value	Odds Ratio (95% CI)	
		Lower	Upper
Age	0.489	0.868	1.070
Male gender	0.438	0.000	35.307
CCI (Charlson's Comorbidity Index)	0.224	0.526	15.499
Emergency surgery due to trauma	0.773	0.009	33.044
Preoperative INR	0.497	0.142	55.727
Cases in which the fascia could be closed	0.081	0.430	1.934.150.054
ERFSGCM	0.999	0.000	-
Packing applied to 2 or more quadrants	0.434	0.001	23.251
Bleeding from liver	0.790	0.002	121.466

surgeries, 16 (55.2%) were emergencies and 13 (44.8%) were elective. In the traditional group, 52% were emergency and 48% elective, while in the ERFSGCM group, 75% were emergency and 25% elective, with no significant difference between groups ($p = 0.606$). All emergency surgeries involved trauma. Trauma types were blunt in 9 patients (56.3%), penetrating in 3 (18.8%), and high-energy in 4 (25%). In the traditional packing group, 9 (69.2%) had blunt, 2 (15.4%) penetrating, and 2 (15.4%) high-energy trauma. In the ERFSGCM group, 1 (33.3%) had penetrating and 2 (66.7%) high-energy trauma; no blunt trauma was observed. Differences in trauma distribution were not significant ($p = 0.080$). Among elective surgeries, 10 patients (71.4%) had iatrogenic bleeding: 9 (69%) in the traditional group and 1 (100%) in the ERFSGCM group, with no significant difference ($p = 1.000$). Bleeding sites included the liver in 11 patients (37.9%; traditional 32%, ERFSGCM 75%), the presacral area in 8 (27.6%; traditional 28%, ERFSGCM 25%), and the retroperitoneum in 8 (27.5%; all traditional, most commonly Zone 2a). No ERFSGCM patients had retroperitoneal bleeding. Differences in bleeding site distribution were not significant ($p = 0.655$). Packing involved one quadrant in 19 patients (65.5%), two in 6 (20.7%), three in 3 (10.3%), and four in 1 (3.4%). In the traditional group, packing was applied to one quadrant in 60%, two in 24%, three in 12%, and four in 4%. All ERFSGCM patients had single-quadrant packing. No significant difference was observed between groups ($p = 0.486$). Median preoperative INR was 1.3 (1.10–1.65) overall, 1.3 (1.08–1.62) in the traditional group, and 1.5 (1.33–1.75) in the ERFSGCM group, with no significant difference ($p = 0.227$). The median intraoperative blood loss (L) was 1.7 (1.2–3.0) for all patients, 1.8 (1.1–3.0) for patients undergoing traditional packing, and 1.5 (1.2–1.6) for patients undergoing packing using the ERFSGCM. There was no significant difference among the groups in terms of intraoperative blood loss ($p = 0.444$). The median intraoperative red blood cell suspension replacement (units) was 4 (2.5–4.5) for all patients, 4 (2–5) for patients undergoing traditional packing, and 4 (3.3–4.0) for patients undergoing packing using the ERFSGCM. The median intraoperative fresh frozen plasma replacement (L) was 2 (2–3) for all patients, 2 (1.5–4.0) for patients undergoing traditional packing, and 2 (2–2) for patients undergoing packing using the ERFSGCM. The median total blood/blood product replacement (units) was 6 (4.5–7.5) for all patients, 6 (4–8)

for patients undergoing traditional packing, and 6 (5.3–6.0) for patients undergoing packing using the ERFSGCM. There were no significant differences between the groups regarding intraoperative replacements ($p = 0.879$, $p = 0.927$, $p = 0.831$). The median number of recurrent active bleeding episodes was 1 (0–1) for all patients, 1 (0–1) for patients undergoing traditional packing, and 0 (0–0) for those undergoing packing using the ERFSGCM. The number of recurrent active bleeding episodes was significantly lower in the ERFSGCM group ($p = 0.043$). The median number of surgeries during admission was 2 (1–3) overall, 2 (1.5–3.5) in the traditional group, and 1 (1–1) in the ERFSGCM group, significantly lower in the latter ($p = 0.013$). Initial abdominal closure methods included skin suturing in 15 patients (51.7%), a Bogota bag in 1 (3.4%), and both fascia and skin suturing in 13 (44.8%). In the traditional group, closure was achieved by skin suturing in 60%, a Bogota bag in 4%, and fascia plus skin suturing in 36%. All ERFSGCM patients underwent fascia and skin closure. Differences between groups were not statistically significant ($p = 0.058$). Postoperative acute renal failure was observed in a total of 15 patients (51.7%). Postoperative acute renal failure was observed in 15 patients (60%) in the traditional packing group, whereas none of the patients in the ERFSGCM group experienced such a complication. Postoperative acute renal failure was significantly less common in the ERFSGCM group ($p = 0.042$). Postoperative ischemic complications were identified in a total of 5 patients (17.9%). Postoperative ischemic complications were observed in 5 patients (20.8%) in the traditional packing group, whereas none were reported in the ERFSGCM group. No significant difference was found between the groups in terms of postoperative ischemic complications ($p=1.000$). Postoperative respiratory distress occurred in 11 patients (37.9%), all from the traditional packing group (44%). No cases were observed in the ERFSGCM group, and the difference was not statistically significant ($p = 0.268$). Anterior abdominal wall fascia was closed in 13 patients (44.8%): 9 (36%) in the traditional group and all in the ERFSGCM group, with significantly higher success in the latter ($p = 0.030$). Sixteen patients (55.2%) were discharged or died with an open fascia, all from the traditional group (64%). Final fascial closure was achieved during the initial surgery in 10 patients (34.5%): 6 (24%) in the traditional group and all in the ERFSGCM group. In the traditional group, closure occurred on postoperative days 1, 5, and 7 in one patient each (4%). No significant difference was observed between groups regarding the timing of closure ($p = 0.066$). Postoperative intra-abdominal abscesses occurred in 3 patients (10.3%), all from the traditional group (12%), with none in the ERFSGCM group ($p = 1.000$). Similarly, wound site infections were observed in 3 patients (10.3%), all in the traditional group (12%), with none in the ERFSGCM group ($p = 1.000$). Median mechanical ventilation was 2 days (1–4.5) overall, 2 (1–5.5) in the traditional group, and 1 (1–1) in the ERFSGCM group, with no significant difference ($p = 0.181$). Median ICU stay was 5 days (4–7.5) overall, 5 (3–8) in the traditional group, and 4.5 (4–5.8) in the ERFSGCM group ($p = 0.647$). Median hospital stay was 16 days (7–41) overall, 20 (6.5–43.5) in the traditional group, and 15.5 (10.5–16.8) in the ERFSGCM group, with no significant difference ($p =$

0.647). Clavien-Dindo scores were 2 in 4 patients (13.8%), 3 in 3 (10.3%), 4 in 4 (13.8%), and 5 in 18 (72%). In the traditional group, no patient scored 2; instead, 3 (12%) scored 3, 4 (16%) scored 4, and 18 (72%) scored 5. All ERFSGCM patients had a score of 2. The difference between groups was significant ($p < 0.001$). Mortality occurred in 18 patients (62.1%), all from the traditional group (72%), while none was observed in the ERFSGCM group, representing a significant difference ($p = 0.014$).

Discussion

Packing is a standard technique in the initial phase of damage control surgery to achieve rapid hemostasis. It is applied in massive hemorrhage when intervention time is limited, aiming to control bleeding through continuous pressure with gauze or compresses. Reported efficacy exceeds 90% [12].

Although indications for packing are well defined, the optimal timing for unpacking remains uncertain. The timing of re-laparotomy is critical for outcomes, yet no gold standard exists. Most studies recommend unpacking within 24–48 hours [13], while in high-grade liver injuries, delaying beyond 48 hours may reduce rebleeding risk. However, prolonged intervals increase infection risk and may hinder successful fascial closure [14]. Pommerening et al. recommended re-laparotomy within 24–48 hours, noting that delays may hinder fascial closure [15]. Abikhaled et al. reported increased infection and abscess risk when packing materials remained beyond 72 hours [16]. Thus, early unpacking has been emphasized, although Nicol et al. found prolonged packing was not associated with higher infection risk [17]. All patients underwent unpacking at 48 hours. Wound infection and abscess occurred in three patients (12%) in the traditional group, while none were observed in the ERFSGCM group. The difference was not statistically significant ($p = 1.000$ for both).

The primary goal of packing is hemostasis, with the absence of recurrent bleeding serving as a key success indicator [2,8,10]. In our study, recurrent bleeding occurred in one patient from the traditional group, while none was observed in the ERFSGCM group. The difference was statistically significant ($p = 0.043$). Traditional packing requires a second-look re-laparotomy for unpacking, adding physiological stress and potential complications [18]. ERFSGCM eliminates this need, offering a significant advantage. In our study, the ERFSGCM group underwent fewer surgeries during hospitalization ($p = 0.013$), supporting its theoretical benefits. Moreover, ERFSGCM enables definitive fascial closure during the initial procedure, whereas multiple surgeries in the traditional method may hinder successful closure [19,20]. In some patients undergoing packing, excessive tension prevents abdominal wall closure. In such cases, temporary closure techniques or planned open management methods, including negative pressure wound therapy or the Bogota bag, are commonly used [21]. In the ERFSGCM group, fascial closure was achieved in all patients, whereas some in the traditional group required alternative methods. Statistical analysis showed a significant difference between groups ($p = 0.030$). In cases without fascial closure, only skin suturing or the Bogota bag technique was used.

Our findings suggest that ERFSGCM facilitates definitive fascial closure more effectively than traditional packing. Although the absence of re-laparotomy may raise concerns regarding intra-abdominal hypertension or compartment syndrome, the technique's design allows gradual withdrawal of the folded gauze, enabling controlled decompression. This feature represents its greatest advantage over the traditional method.

Postoperative acute renal failure was significantly less frequent in the ERFSGCM group ($p = 0.042$). Clavien-Dindo scores ($p < 0.001$) and mortality ($p = 0.014$) were also significantly lower, with ERFSGCM further associated with fewer overall complications.

Our findings suggest that ERFSGCM is at least as safe and effective as traditional packing, with evidence of superior outcomes. By eliminating the need for re-laparotomy and reducing the number of surgeries, ERFSGCM also demonstrates greater cost-effectiveness compared to the traditional method.

Limitations

Although our hospital is not a specialized trauma center, it serves as one of the key facilities in our region for the admission and treatment of emergency trauma patients. Despite this fact, the small sample size in our study poses a limitation in terms of statistical analysis. Although the patient sample size in our study is relatively small, its pioneering nature makes it a significant contribution to the literature.

Conclusion

The use of ERFSGCM as an alternative to the traditional packing method in patients with massive intra-abdominal hemorrhage can eliminate the need for re-laparotomy for unpacking. Furthermore, based on the results of our study, ERFSGCM demonstrates a more favorable profile regarding postoperative complications and mortality compared to traditional packing. However, further studies with larger patient populations are needed to establish the superiority of the ERFSGCM.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content, including study design, data collection, analysis and interpretation, writing, and some of the main line, or all of the preparation and scientific review of the contents, and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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